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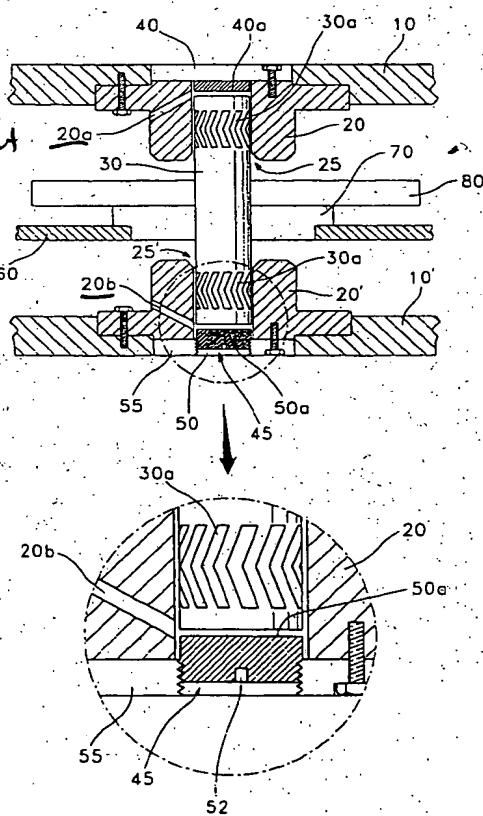
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### (54) Fluid bearing apparatus

(57) A fluid bearing apparatus wherein a clearance between a surface of a thrust bearing (50) supporting thrust load and a periphery of a rotary shaft (30) can be adjusted by making the thrust bearing (50) movable with respect to an end portion of the rotary shaft, preferably by means of a thrust bearing support (55) having a threaded through hole (45) for receiving a corresponding threaded thrust bearing (50). This results in an enhanced efficiency and a stable rotation of the rotary shaft at a high velocity.

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FIG. 2



## D scription

The present invention relates to a fluid bearing apparatus and, in the preferred embodiment, to a fluid bearing apparatus such as may be employed in a laser printer or other device.

Figure 1 is a sectional view of a prior art fluid bearing apparatus.

As shown in the drawing, a thrust bearing 50 is installed at an end of a through hole 25 in a sleeve 20. A rotary shaft 30 is inserted into the sleeve 20. A lower end portion of the shaft 30 faces the thrust bearing 50 which supports a vertical thrust load of the shaft 30. A first dynamic pressure generating groove 50a is formed on the upper surface of the thrust bearing 50. The sleeve 20 is fastened to the thrust bearing 50 with a clamp screw or the like. In the sleeve 20, an air vent 20a is formed to ventilate air between the thrust bearing 50 and the shaft 30. Furthermore, a second dynamic pressure generating groove 30a having a herringbone shape is formed on the outer surface of the shaft 30 inserted into the through hole 25, or the inner peripheral surface of the sleeve 20.

When the shaft 30 is revolved, a clearance is created between the thrust bearing 50 and the lower end portion of the rotary shaft 30. When the clearance is wide, the shaft 30 may vibrate and oscillate. On the other hand, when the clearance is narrow, a high pressure and heat are generated between the lower end portion of the shaft 30 and the thrust bearing 50. Heat causes the thrust bearing 50 and the shaft 30 to fuse with each other. As a result, the revolution of the shaft 30 may be stopped. For this reason, the clearance between the lower end portion of the shaft 30 and the thrust bearing 50 is a critical factor of high accuracy and high speed revolution of the fluid bearing apparatus.

In the conventional fluid bearing apparatus, the clearance is extremely narrow in the range of several to several dozens  $\mu\text{m}$ . Accordingly, an actual clearance during the operation of the bearing apparatus may be different from originally designed clearance between the surface of the thrust bearing 50 and the lower end portion of the shaft 30 due to a variation in the length of the shaft 30 or in the depth of the dynamic pressure generating groove. In addition, friction and abrasion of the thrust bearing and the shaft in repeatedly using the bearing apparatus cause the clearance between the bearing and the shaft to be wider than the originally designed clearance. Therefore, there is needed an adjustment of the clearance between the thrust bearing and the shaft for using the bearing apparatus.

However, there is a disadvantage that after the thrust bearing and the shaft are assembled, it is impossible to adjust the clearance between the thrust bearing and the shaft in the fluid bearing apparatus according to the embodiment of the conventional art.

An aim of at least preferred embodiments of the present invention is to overcome the above described

problem of the conventional art where a clearance between a shaft and a thrust bearing is not adjustable.

According to the present invention there is provided a fluid bearing apparatus comprising: a sleeve coupleable to a bearing bracket, said sleeve having a through hole for receiving a rotary shaft; and a thrust bearing locatable in use at a position opposed to an end portion of said rotary shaft; characterised by: a thrust bearing moving unit for moving said thrust bearing with respect to the end portion of the rotary shaft.

Preferably, the thrust bearing moving unit includes a thrust bearing support coupled to the bearing bracket; and the thrust bearing movably inserted into the thrust bearing support. More preferably, the thrust bearing support includes a screw hole formed therein, and the thrust bearing includes a screw thread on periphery thereof, the spiral surface of the thrust bearing engaged with a corresponding screw thread on the inner circumference of the screw hole. Preferably, the thrust bearing includes a screw slot formed on a side thereof for rotating and moving the thrust bearing. Selectively, the thrust bearing includes a knob formed on the side thereof for rotating and moving the thrust bearing.

Preferably, the thrust bearing includes a surface opposed to the rotary shaft and having a hemispherical shape.

Preferably, the fluid bearing apparatus comprises: said sleeve installed at a side of a bearing bracket; a rotary shaft inserted into said through hole formed in the sleeve, and having a second dynamic pressure generating groove formed on an outer surface of the rotary shaft facing an inner peripheral surface of the through hole; said thrust bearing installed at a position opposed to an end portion of the rotary shaft, and having a first dynamic pressure generating groove on a surface of the thrust bearing opposed to an end portion of the rotary shaft.

Furthermore, the fluid bearing apparatus preferably includes: an upper and a lower sleeves respectively installed at an end of an upper and a lower bearing brackets; a rotary shaft inserted into an upper and a lower through holes respectively formed in the upper and the lower sleeves, and having a second dynamic pressure generating groove on an outer surface of the rotary shaft facing the inner periphery of the through holes; and an upper and a lower thrust bearings installed at positions respectively opposed to end portions of the rotary shaft, and each having a first dynamic pressure generating groove on the surfaces of the upper and the lower thrust bearings opposed to the end portions of the rotary shaft; and a thrust bearing support installed at the other side of one of the bearing brackets, any of the upper and the lower thrust bearings movably inserted into the thrust bearing support.

Preferably, the thrust bearing support is installed at the other side of the other of the bearing brackets; and one of the thrust bearings is movably inserted into the thrust bearing support.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 1 is a sectional view of a prior art thrust bearing;

Figure 2 is a sectional view of a thrust bearing according to an embodiment of the present invention, which is applied to a polygonal mirror driving apparatus of a laser printer; and

Figure 3 is a sectional view of a thrust bearing according to another embodiment of the present invention.

A fluid bearing apparatus according to a preferred embodiment of the present invention will be described in detail with reference to Figure 2 and 3 of the accompanying drawings.

Referring to Figure 2, an upper and a lower sleeve 20 and 20' are each inserted into one end of an upper and a lower bearing bracket 10 and 10' respectively, and are fastened to the brackets 10 and 10' by means of clamp screws. An upper thrust bearing 40 is inserted into the other end of the upper bearing bracket 10, and is fastened to the upper sleeve 20 by means of a clamp screw. A lower thrust bearing 50 and a thrust bearing support 55 are inserted into the other end of the lower bearing bracket 10', and are fastened to the lower sleeve 20' by means of a clamp screw.

Upper and lower through holes 25 and 25' are respectively formed in the upper and the lower sleeves 20 and 20'. A rotary shaft 30 is inserted into the through holes 25 and 25'. The upper and the lower sleeves 20 and 20' respectively have air vents 20a and 20b for exhausting air between the shaft 30 and the upper thrust bearing 40 and between the shaft 30 and the lower thrust bearing 50, or for preventing any change in the air pressure in association with a volume expansion of the above components due to a change in the temperature.

On a peripheral surface of the shaft 30 inserted into the through holes 25 and 25' in the upper and the lower sleeves 20 and 20', or on an inner periphery of the sleeves 20 and 20' facing the peripheral surface of the shaft 30, a second dynamic pressure generating groove 30a having a herringbone shape is formed. Preferably, the angle between the second dynamic pressure generating groove 30a and a line which is horizontal with respect to the bearing brackets 10 and 10' and crosses angled points of the second dynamic pressure generating groove 30a is approximately thirty degree, and the depth of the groove is several  $\mu\text{m}$ .

A first dynamic pressure groove 40a having a spiral groove is formed on the surface of the upper thrust bearing 40 facing an upper end portion of the shaft 30. Prefer-

ably, the spiral shaped groove has a depth of several  $\mu\text{m}$  by an etching process.

The embodiment shown in Figure 2 may be used in a variety of applications, including, for example, a laser printer. In this example, a polygonal mirror 80 for reflecting a laser beam to a light-sensitive drum (not shown) of a laser printer and a hub 70 are fixed to the center portion of the shaft 30. A plate 60 (partially shown) is jointed to the hub 70 so that the shaft 30 revolves together with the plate 60 when the plate 60 is rotated.

A screw hole 45 having a predetermined diameter is formed at the center of the thrust bearing support 55. Preferably, the diameter of the screw hole 45 corresponds to the diameter of the through hole 25' of the sleeves 20'. The lower thrust bearing 50 has a diameter corresponding to the diameter of the screw hole 45, and includes a spiral surface which is engaged with the inner peripheral surface of the screw hole 45. A first dynamic pressure generating groove 50a having a spiral groove is formed on the surface of the lower thrust bearing 50 facing a lower end portion of the shaft 30. Preferably, a screw hole 52 is formed at the bottom of the lower thrust bearing 50.

The operation of the fluid bearing apparatus according to the embodiment of the present invention applied to a polygon mirror driving scanner motor of a laser printer will be described hereinafter.

First, the upper sleeve 20 is inserted into and fixed to a side of the upper bearing bracket 10, and the upper thrust bearing 40 is inserted into and fixed to the other side of the upper bearing bracket 10. The lower sleeve 20' is inserted into and fixed to a side of the lower bearing bracket 10', and the lower thrust bearing support 55 is inserted into and fixed to the other side of the lower bearing bracket 10'. Thereafter, the lower thrust bearing 50 is inserted into the screw hole 45 of the lower thrust bearing support 55 and it is engaged with the lower thrust bearing support 55.

The rotary shaft 30 is then inserted into the sleeves 20 and 20' fixed to the upper and the lower brackets 10 and 10'. The hub 70 to which the polygonal mirror 80 and the plate 60 are jointed, is fixed to the shaft 30 in advance. The scanner motor is completed by incorporating the upper and the lower brackets 10 and 10' with each other.

If power is supplied to the scanner motor, the plate 60 is rotated. The shaft 30 is then revolved together with the polygonal mirror 80 fixed to the shaft 30 when the plate 60 is rotated. A fluid introduced into the first dynamic pressure generating grooves 40a and 50a formed on the surfaces of the upper and the lower thrust bearings 40 and 50 facing the upper and the lower end portions of the shaft 30 flows from the edge portions into the center portions of the grooves 40a and 50a. As a result, a predetermined fluid pressure is generated and the shaft 30 is revolved without contacting with the upper and the lower thrust bearings 40 and 50.

In the event that the clearance between the lower

thrust bearing 50 and the shaft 30 is not sufficient or is excessive, the shaft 30 is not capable of revolving at a high velocity. This results in movement and vertical oscillation of the shaft 30.

According to the embodiment of Figure 2; when the movement and vertical oscillation of the shaft 30 occur, the clearance between the lower thrust bearing 50 and the lower end portion of the shaft 30 can be adjusted by rotating the lower thrust bearing 50 using the screw hole 52 formed at the bottom of the lower thrust bearing 50. For example, if the screw hole 52 is revolved in the clockwise direction, the lower thrust bearing 50 is moved up. As a result, the clearance is reduced. If the screw hole 52 is revolved in the counter-clockwise direction, the lower thrust bearing 50 is moved down. As a result, the clearance is enlarged. In this manner, the clearance can be suitably adjusted according to the revolution state of the shaft 30 so that the shaft can be revolved at a high velocity or at a constant velocity.

Figure 3 is a sectional view of another fluid bearing apparatus according to another embodiment of the present invention. For description purposes, elements having basically the same function as previously described elements are identified using similar reference numbers in the drawing, and description thereof is omitted below.

In this embodiment, a lower thrust bearing 50' has a diameter corresponding to the diameter of a screw hole 45 and includes a spiral surface formed on periphery thereof. The spiral surface of the lower thrust bearing 50' is engaged with the spiral surface formed on the inner periphery of the screw hole 45. The surface of the lower thrust bearing 50' facing the lower end portion of the shaft 30 has a hemispherical shape. Accordingly, the lower thrust bearing 50' makes a point-contact with the end portion of the shaft 30. A first dynamic pressure generating groove 50a having a spiral surface having a predetermined area is formed on its surface facing the shaft 30. Preferably, a screw hole 52 is formed at the bottom of the lower thrust bearing 50'.

According to this second embodiment, since the lower end portion of the shaft 30 point-contacts with the lower thrust bearing 50' even when the shaft 30 is at a standstill, friction can be minimized.

In the event that the shaft 30 is vibrated or oscillated, the clearance between the lower thrust bearing 50' and the shaft 30 can be adjusted in the same manner described with the first embodiment without any degradation of the efficiency.

As aforementioned, the clearance between the shaft and the thrust bearing which supports the thrust load can be adjusted by making the lower thrust bearing longitudinally or axially movable with respect to the shaft. For example, the thrust bearing may be jointed to the thrust bearing support by means of a screw, but other arrangements will be apparent to the skilled person. The result is an enhanced efficiency of the fluid bearing apparatus capable of revolving the shaft at a stable high

velocity.

This invention has been described above with reference to the preferred embodiments. It is evident, however, that many alternative, modification and variations will be apparent to those skilled in the art in light of the foregoing description. In other words, the present invention is not restricted to the above embodiments of the lower thrust bearing, and it is clearly understood that it can be applied to the upper thrust bearing. The present invention may further include a knob attached to the screw hole formed at the bottom of the thrust bearing for facilitation.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

## Claims

1. A fluid bearing apparatus comprising:

a sleeve (20) coupleable to a bearing bracket (10), said sleeve having a through hole (25) for receiving a rotary shaft, and

a thrust bearing (50) locatable in use at a position opposed to an end portion of said rotary shaft;

characterised by:

a thrust bearing moving unit (50, 55) for moving said thrust bearing (50) with respect to the end portion of the rotary shaft.

2. The fluid bearing apparatus of claim 1, wherein said thrust bearing moving unit (50, 55) comprises:

a thrust bearing support (55) coupleable to the bearing bracket (10), and

said thrust bearing (50) being movably inserted into said thrust bearing support (55).

3. The fluid bearing apparatus of claim 2, wherein said thrust bearing support (55) includes a screw thread (45) formed therein, and said thrust bearing (50) includes a co-operating screw thread formed on a side thereof.

4. The fluid bearing apparatus of Claim 3, wherein said thrust bearing (50) includes a screw slot (52) or a knob formed on a lower surface thereof for rotating and moving said thrust bearing (50).

5. The fluid bearing apparatus as claimed in any of claims 1 to 4, wherein a surface of said thrust bearing (50') opposed to an end portion of the rotary shaft has a hemispherical shape.

6. A fluid bearing apparatus as claimed in any of claims 1 to 5, wherein

said sleeve (20) is installed at a side of a bearing bracket (10);

a rotary shaft (30) is inserted into said through hole (25) formed in said sleeve (20), said rotary shaft (30) having a second dynamic pressure generating groove (30a) formed on an outer surface thereof facing an inner surface of the through hole (25); and

said thrust bearing (50) is installed at a position opposed to an end portion of said rotary shaft (30) and has a first dynamic pressure generating groove (50a) on a surface thereof opposed to an end portion of the rotary shaft.

7. A fluid bearing apparatus as claimed in any of claims 1 to 5, comprising:

a first sleeve (25) and a second sleeve (25'), said first sleeve installed at a side of a first bearing bracket (10) and said second sleeve (25') installed at a side of a second bearing bracket (10') opposed to said first bearing bracket;

a rotary shaft (30) respectively inserted into first and second through holes (25, 25') which are respectively formed in said first and said second sleeves and having a second dynamic pressure generating groove (30a) on an outer

surface thereof facing the inner surface of each said through holes;

a first and a second thrust bearing (40, 50) respectively installed at a position opposed to end portions of said rotary shaft, and respectively having a first dynamic pressure generating groove (40a, 50a) on a surface thereof opposed to the end portions of said rotary shaft; and

a thrust bearing support (55) installed at an opposing side of one of said bearing brackets, said first and/or said second thrust bearings (50) being movably inserted into said thrust bearing support (55).

20

25

30

35

40

45

50

55

FIG. 1  
(Prior Art)

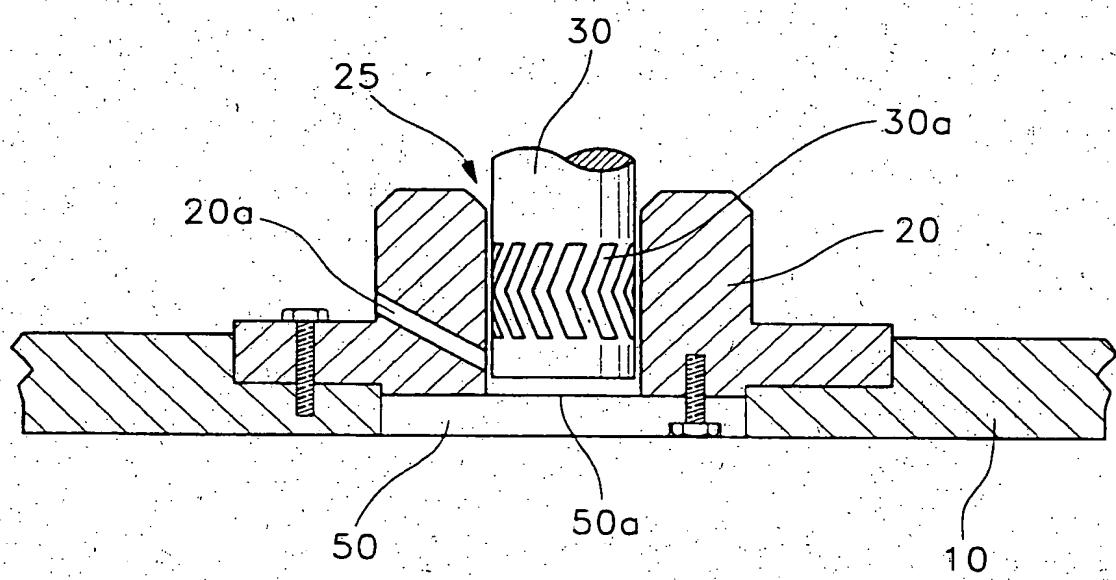


FIG. 2

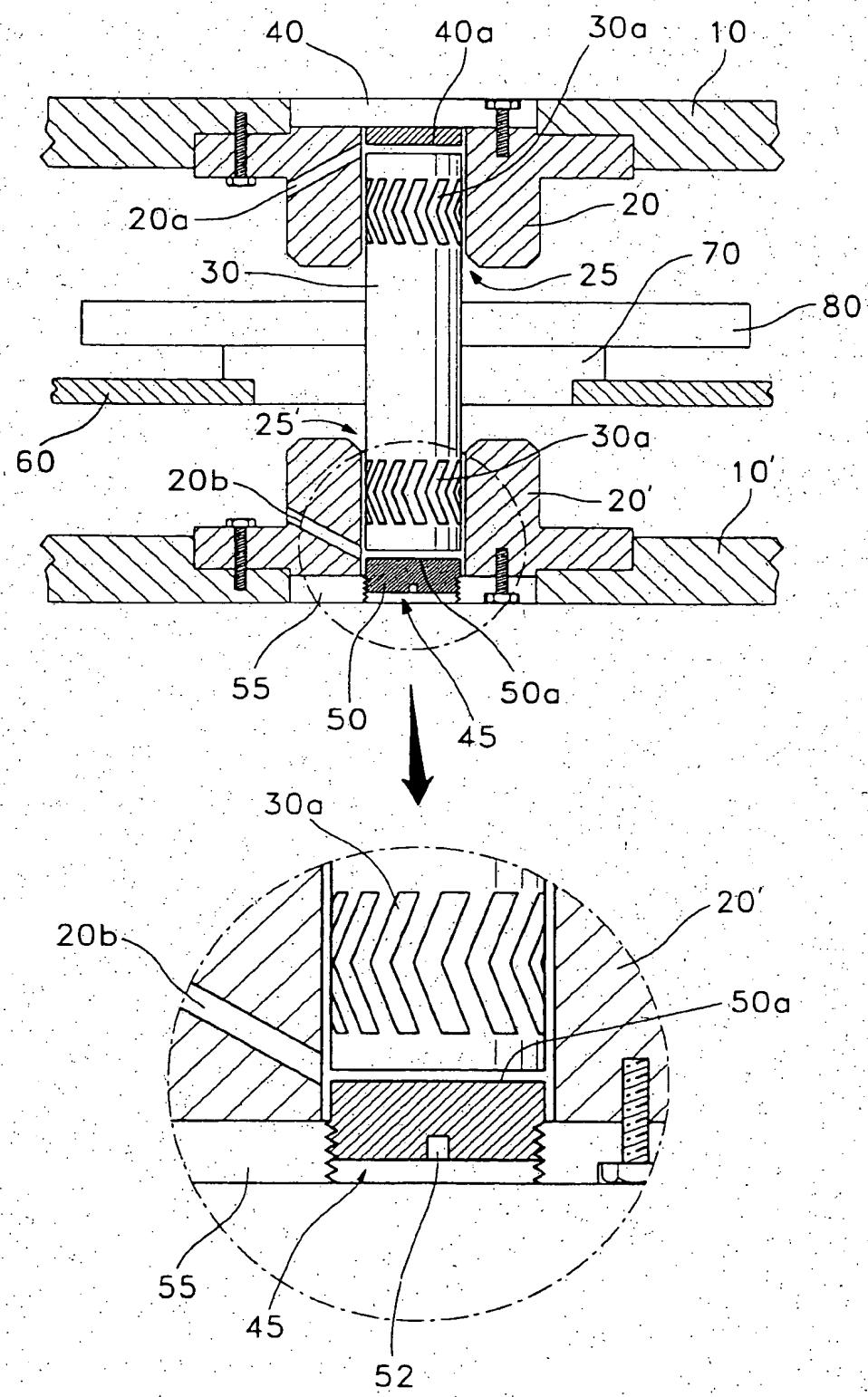


FIG. 3

